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14. ABSTRACT This is the interim progress report of agreement number: W911NF-09-1-0293. Research topic is "Performance Limits of Non-Line-of-Sight Optical Communications". Report Period is August 2011 to January 2012. During this report period, the following have been achieved: 1. Developed a long distance UV channel test bed. 2. Proposed a Neighbor Discovery Protocol for UV network.					
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Report Title

Performance Limits of Non-Line-of-Sight UV Communications

ABSTRACT

This is the interim progress report of agreement number: W911NF-09-1-0293. Research topic is "Performance Limits of Non-Line-of-Sight Optical Communications". Report Period is August 2011 to January 2012. During this report period, the following have been achieved:

1. Developed a long distance UV channel test bed.
2. Proposed a Neighbor Discovery Protocol for UV network.
3. Modeled long distance NLOS UV channel
4. Designed a UV communication system working on USRP software defined radio platform.

Performance Limits of Non-Line-of-Sight UV Communications

Progress report
1 August 2011–1 January 2012

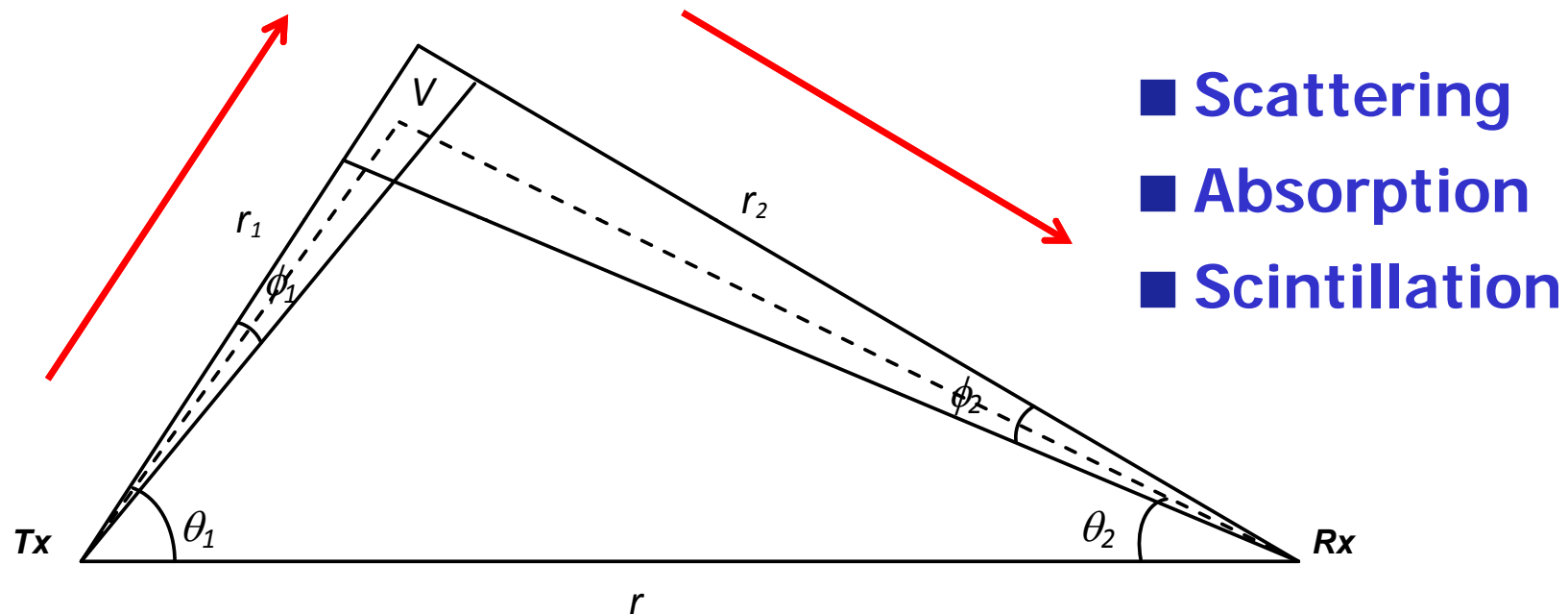
Gang Chen

University of California, Riverside, CA 92521

<http://witlab.ee.ucr.edu>

gachen@ee.ucr.edu

1. Turbulence modeling for NLOS UV scattering channels



- $\text{NLOS} = \text{LOS (Tx} \rightarrow \text{V)} + \text{LOS (V} \rightarrow \text{Rx)}$
- LOS path follow LN PDF

NLOS UV Scintillation Model

Tx -> V: PDF at the common volume

$$f_x(x) = \frac{1}{x\sigma_x\sqrt{2\pi}} \exp\left(-\frac{\left(\ln\frac{x}{E[x]} + \frac{1}{2}\sigma_x^2\right)^2}{2\sigma_x^2}\right)$$

V -> Rx: assume single scattering

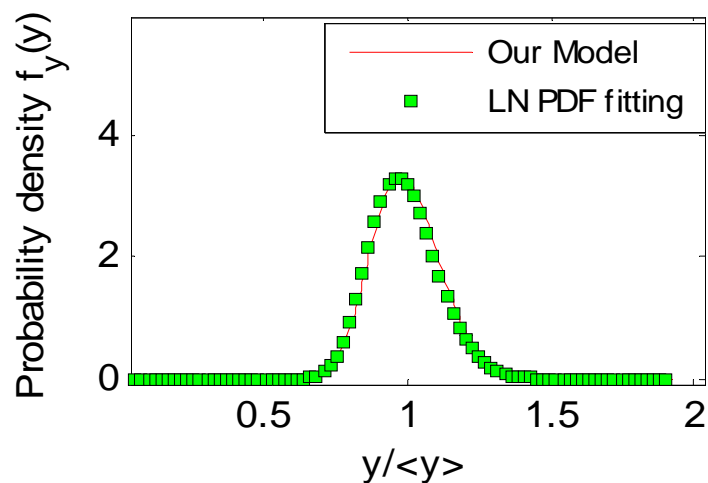
$$f_y(y|x) = \frac{1}{y\sigma_y\sqrt{2\pi}} \exp\left(-\frac{\left(\ln\frac{y}{E[y|x]} + \frac{1}{2}\sigma_y^2\right)^2}{2\sigma_y^2}\right) \quad \text{Conditional PDF}$$

$$f_{x,y}(x,y) = f_y(y|x)f_x(x) \quad \text{Joint PDF}$$

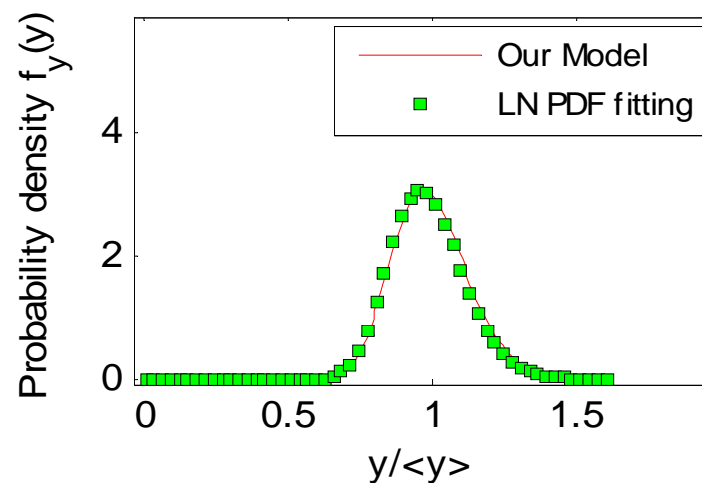
$$f_y(y) = \int f_{x,y}(x,y)dx \quad \text{PDF at Rx}$$

Primary results

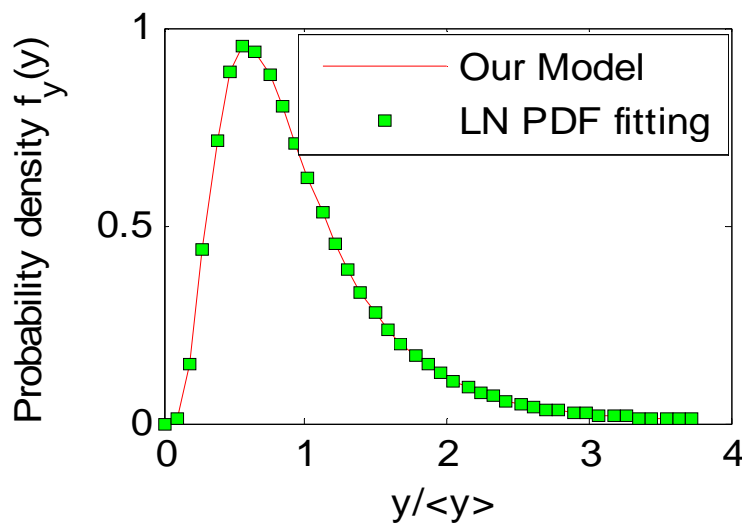
Scitillation PDF for $(\theta_1, \theta_2) = (20^\circ, 20^\circ)$



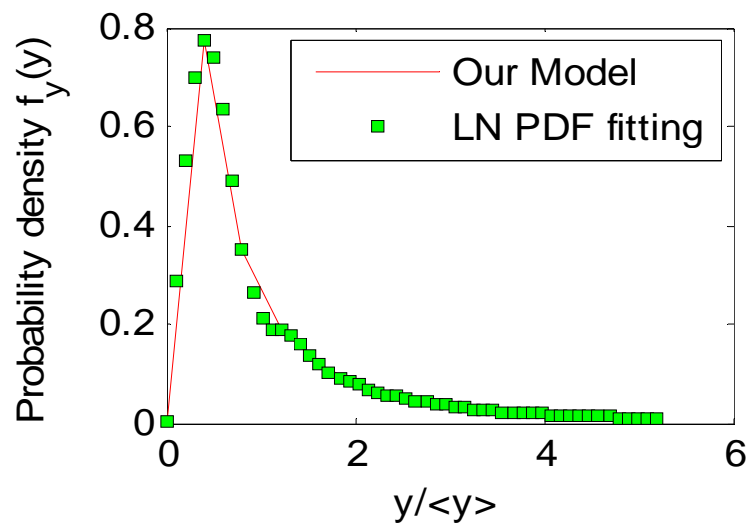
Scitillation PDF for $(\theta_1, \theta_2) = (30^\circ, 30^\circ)$



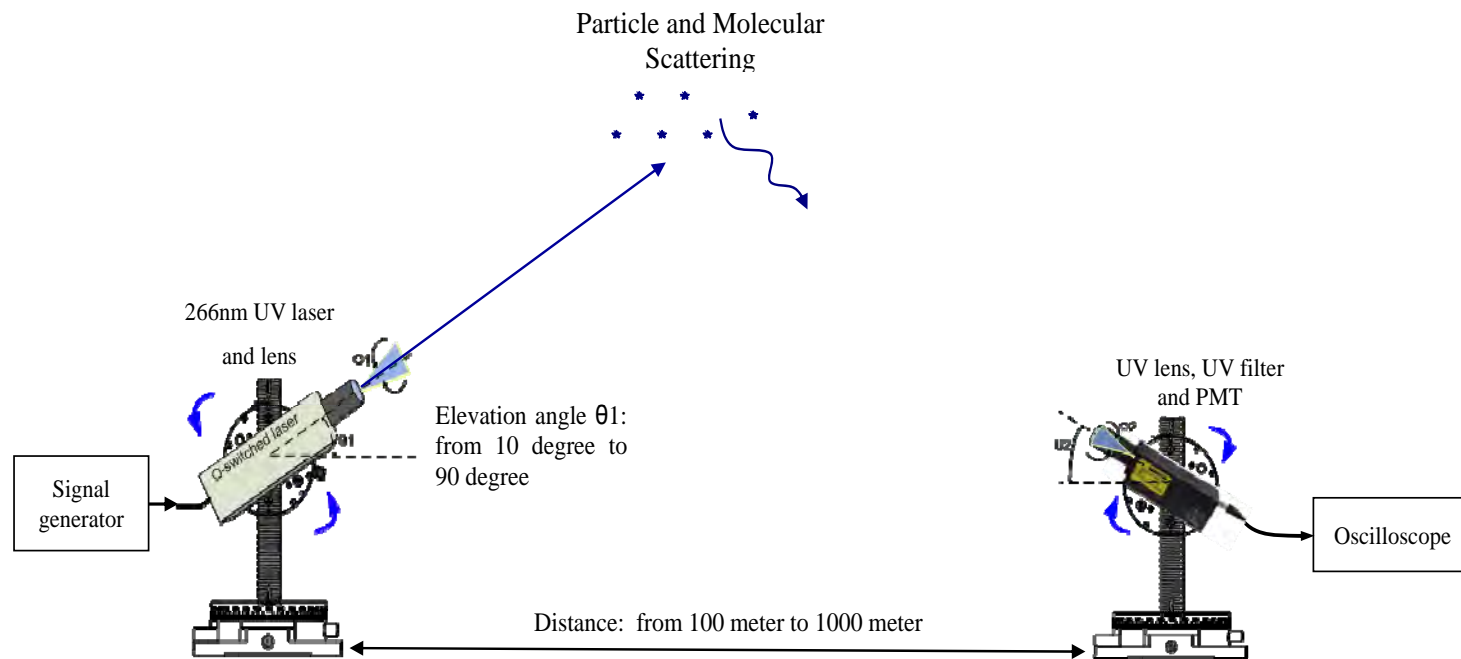
Scitillation PDF for $r=500m$



Scitillation PDF for $r=1000m$



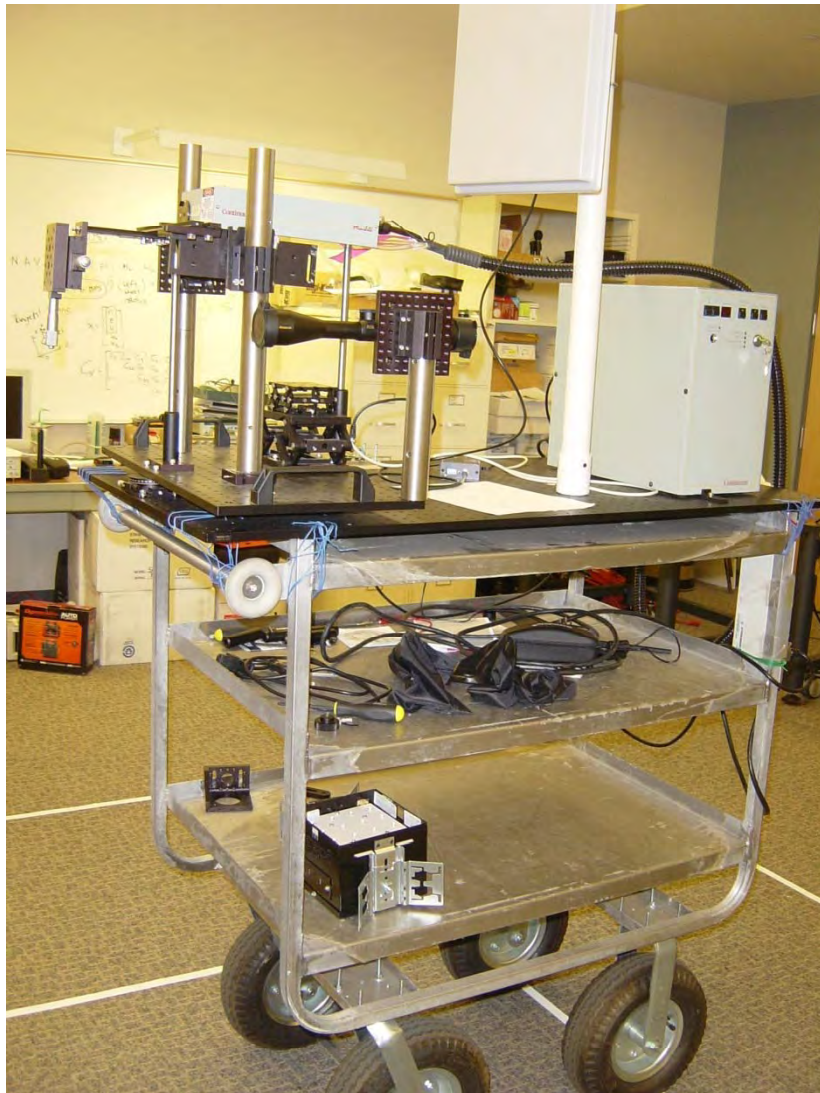
2. UV long distance test bed



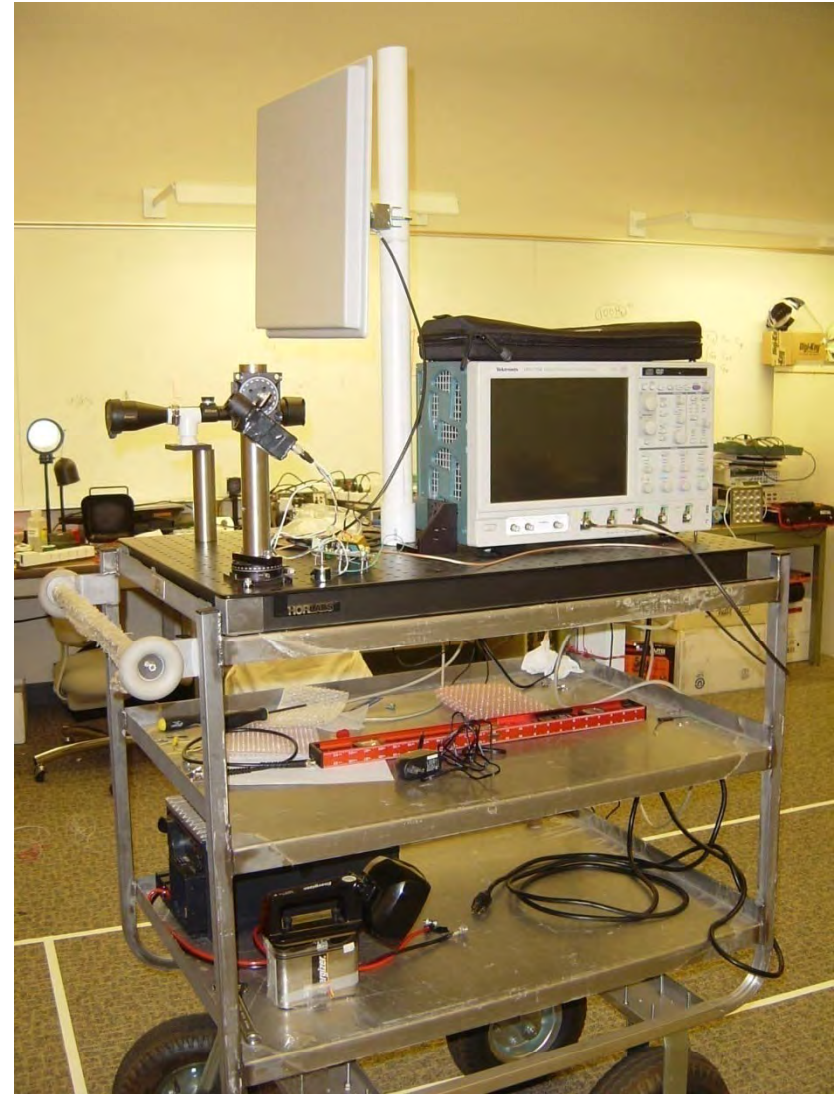
Transmitter :Q-switched fourth harmonic Nd:YAG laser at 266nm
 15 Hz with pulse width (3-5) ns and energy (3-5) mJ
 Rotation angle θ_1 $10^\circ - 90^\circ$

Receiver: PMT detector +high speed preamplifier \rightarrow 3 GHz oscilloscope
 Waveform record

UV test bed picture



Laser Transmitter



PMT+ Osc Recorder

3. UV system design on SDR platform



SFF-SDR from Lyrtech

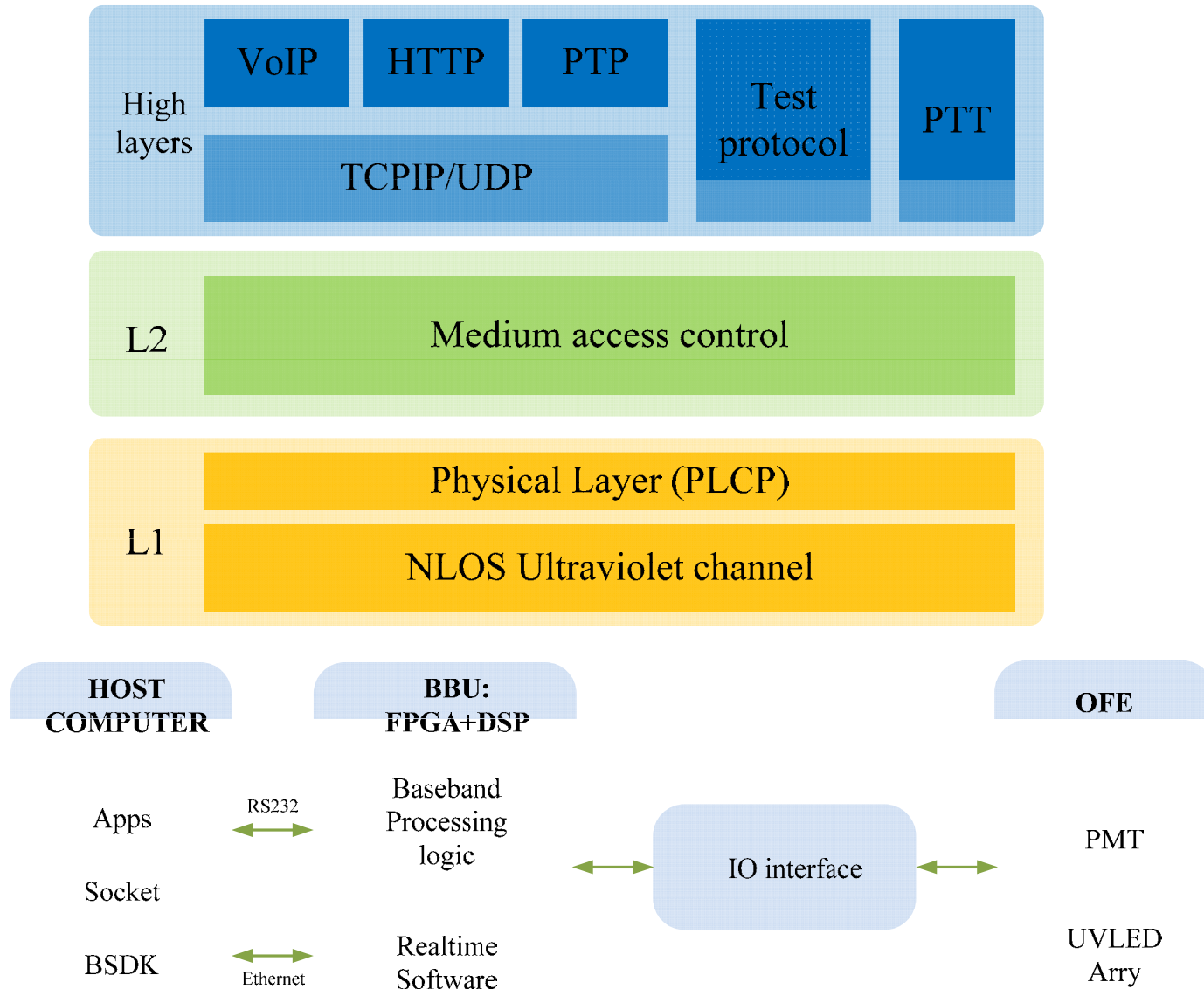
- TMS320DM6446 DM SoC
- 128MB DDR2 SDRAM
- Virtex-4 SX35 FPGA
- 125MSPS, 14-bit ADCs
- Dual channel 500MSPS, 16bit DACs



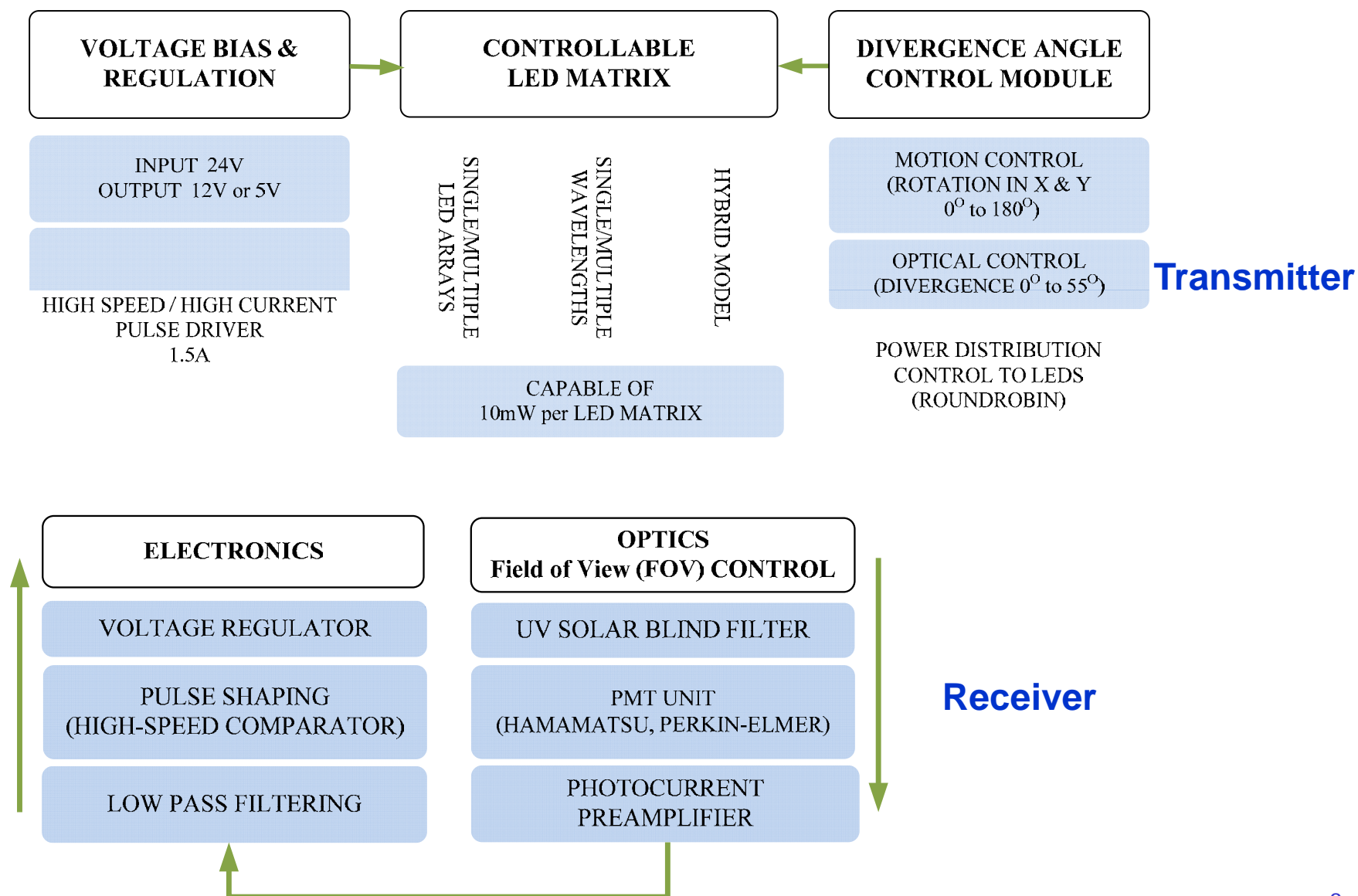
The USRP2 from GNU Radio

- Two 100 MS/s 14-bit ADC
- Two 400 MS/s 16-bit DAC
- Gigabit Ethernet Interface
- 2 Gbps high-speed serial interface
- Modular RF daughter boards
- Fully MIMO capable up to 8 nodes
- 1 Megabyte high-speed SRAM

UV on SDR Architecture and Protocol



Optical front end design



Future Work

- Analytical UV long distance model
- UV long distance channel test and model validation
- Multi-node system protocols design
- Implementation UV front end based on USRP software defined radio platform